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Technical Support Package

Cup Cylindrical Waveguide Antenna

NASA Tech Briefs
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National Aeronautics and
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Technical Support Package

for

CUP CYLINDRICAL WAVEGUIDE ANTENNA

LEW-18089-1

NASA Tech Briefs

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Cup Cylindrical Waveguide Antenna

Brief Abstract

The cup cylindrical waveguide antenna (CCWA) is a novel type of short backfire antenna. The CCWA is a dual reflector system consisting of a circular waveguide feed, circular disk subreflector, and a circular cup. To achieve circular polarization, a compact, 6-post polarizer is integrated into the circular waveguide. The circular waveguide also includes an orthomode transducer (OMT) with coaxial ports to achieve simultaneous dual polarization. This reduces the overall length of the OMT and polarizer to about 11” compared to about 32” for a commercially available model. The innovators developed this antenna as a potential candidate for the Tracking and Data Relay Satellite System (TDRSS) -Continuation Project, which is the follow-on to the TDRSS class of satellites identified as F1-F10.

Section I — Description of the Problem

General Description:
Develop compact antenna element with the following specifications.

Frequency (GHz)	2.2 – 2.3
Directivity (dBi)	15
Axial Ratio (dB)	>–5 dB

Polarization: Simultaneous Left Hand Circular Polarization and Right Hand Circular Polarization

Beam width (degs)	±20
Return loss (dB)	≤–20
Isolation (dB)	≤–10

C.
Prior TDRSS multiple access elements included microstrip patch antennas and helix antennas.

D.
The patch antennas suffered reliability issues and the helix is not able to obtain simultaneous polarizations.

Section II — Technical Description

Please see attached documentation

Section III — Unique or Novel Features

Short Backfire Antennas (SBAs) are widely utilized for mobile satellite communications, tracking, telemetry, and wireless local area network (WLAN) applications due to its compact structure and excellent radiation characteristics [1-3]. Typically, these SBA’s consist of a half-wavelength dipole excitation element for linear polarization or crossed half-wavelength dipole elements for circular polarization. To achieve simultaneous dual circular polarization would require integrating a network of hybrid components, which introduces significant losses. Alternatively, we have integrated an orthomode transducer and polarizer into a circular waveguide exciter. This configuration offers a compact device providing simultaneous circular polarization.

[1] Y. Yamada, T. Takan, and N. Ishida, “Compact antenna equipment for maritime satellite communication systems,” Trans. IEICE, vol. 62-B, pp. 844-846, 1979.

[2] S. Yang, S.H. Tan, and J.S. Fu, “Short backfire antennas for wireless LAN applications at millimeter-waves,” in IEEE AP-S Int. Symp., vol. 3, pp.1260-1263, Jul. 2000.

[3] H.W. Ehrenspeck, “The backfire antenna, a new type of directional line source,” Proc. IRE, vol. 48, no. 1, pp. 109-110, Jan. 1960.

Section IV — Potential Commercial Applications

This device holds potential for mobile satellite communications, tracking, telemetry, and wireless local area network (WLAN) applications due to its compact structure and excellent radiation characteristics.

Cup Cylindrical Waveguide Antenna

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Abstract
This document describes a novel cup cylindrical waveguide antenna (CCWA) developed as a potential candidate for the Tracking and Data Relay Satellite System (TDRSS) -Continuation Project, which is the follow-on to the TDRSS class of satellites identified as F1-F10.

Introduction
The Tracking and Data Relay Satellite System (TDRSS) is a constellation of geosynchronous satellites, which are the primary source of space-to-ground voice, data and telemetry for the Space Shuttle [i]. The satellites also provide communications with the International Space Station and scientific spacecraft in low-Earth orbit such as the Hubble Space Telescope. Integral to the design of the TDRSS class of satellites is an architecture consisting of a multiple access (MA), S-band, phased array antenna. This MA system receives and relays data simultaneously from five lower data-rate users and transmits commands to a single user.

The TDRSS-Continuation Project is the follow-on to the TDRSS class of satellites identified as F1-F10. The specific goals are to enhance the MA array antenna elements for greater on-axis gain, simultaneous polarization capability, and increased beam width. The design specifications for the enhanced MA antenna elements are summarized in Table 1. This paper describes a study (design, fabrication, and testing) of the cup circular waveguide antenna (CCWA), which is a candidate for the enhanced MA phased array.

Table 1 TDRSS Enhanced MA antenna element specifications.

Frequency (GHz)	2.2 – 2.3
Directivity (dBi)	15
Axial Ratio (dB)	> -5 dB
Polarization	Simultaneous LHCP and RHCP
Beam width (degs)	+/- 20
Return loss (dB)	≤ -20
Isolation (dB)	≤ -10

The CCWA is a novel type of short backfire antenna, which is a dual reflector system consisting of a circular waveguide feed, circular disk subreflector, and a circular cup. This antenna is shown in Figure 1. To achieve circular polarization, a compact, 6-post polarizer is integrated into the circular waveguide similar to that described in [ii]. The circular waveguide also includes an orthomode transducer (OMT) with coaxial ports to achieve dual polarization. This reduces the overall length of the OMT and polarizer to about 11" compared to about 32" for a commercially available model.

Figure 1 Cup circular waveguide antenna.

Design

The CCWA was designed using the three-dimensional electromagnetic software, Microwave Studio [iii]. The built in optimizer was used with user defined goal functions to optimize the device for directivity, axial ratio, return loss and isolation. The final dimensions for the antenna, OMT and polarizer are detailed in Figure 3Figure 2 - Figure 4.

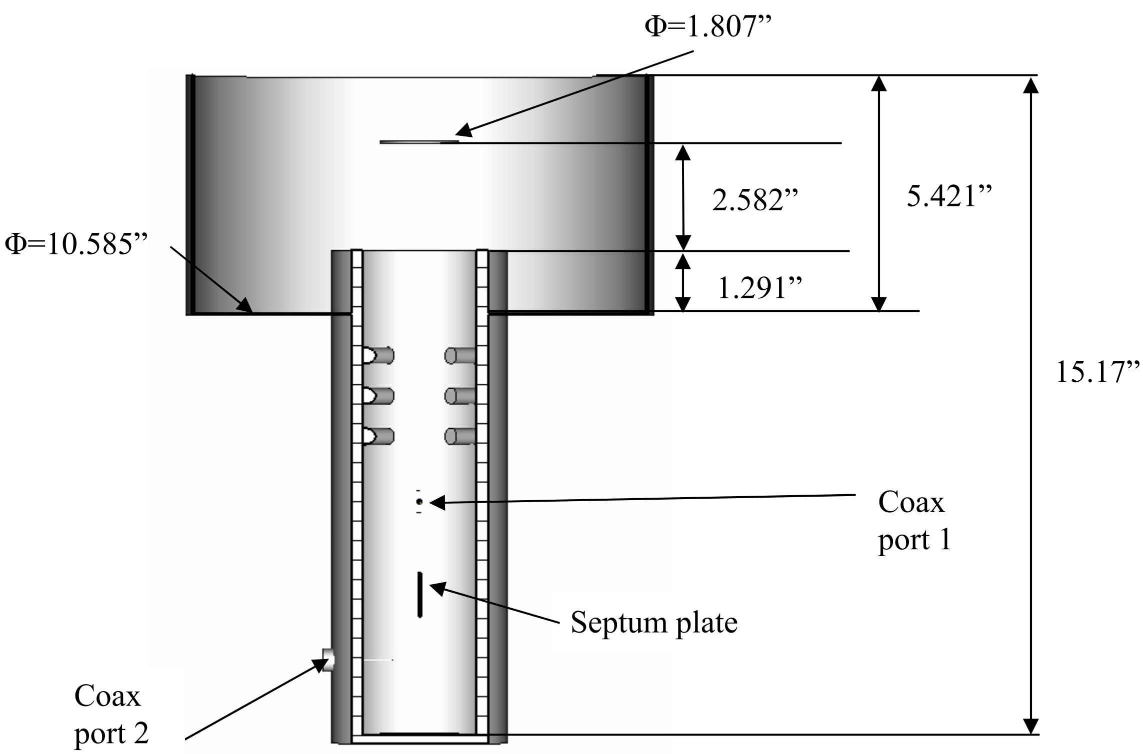


Figure 2 Cut through view of CCWA with dimenions in inches.

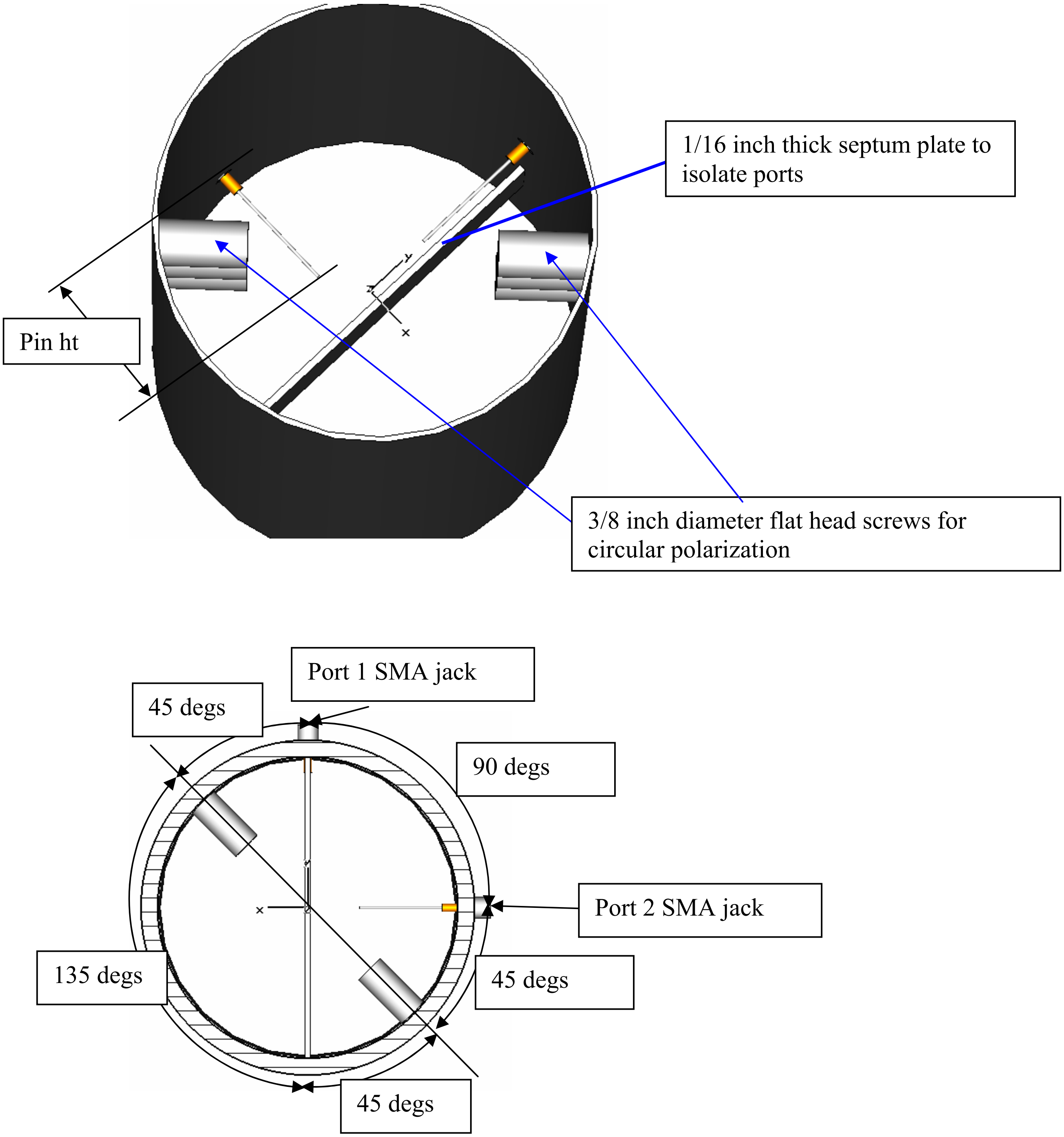


Figure 3 Details for orthomode transducer (OMT) and polarizer.

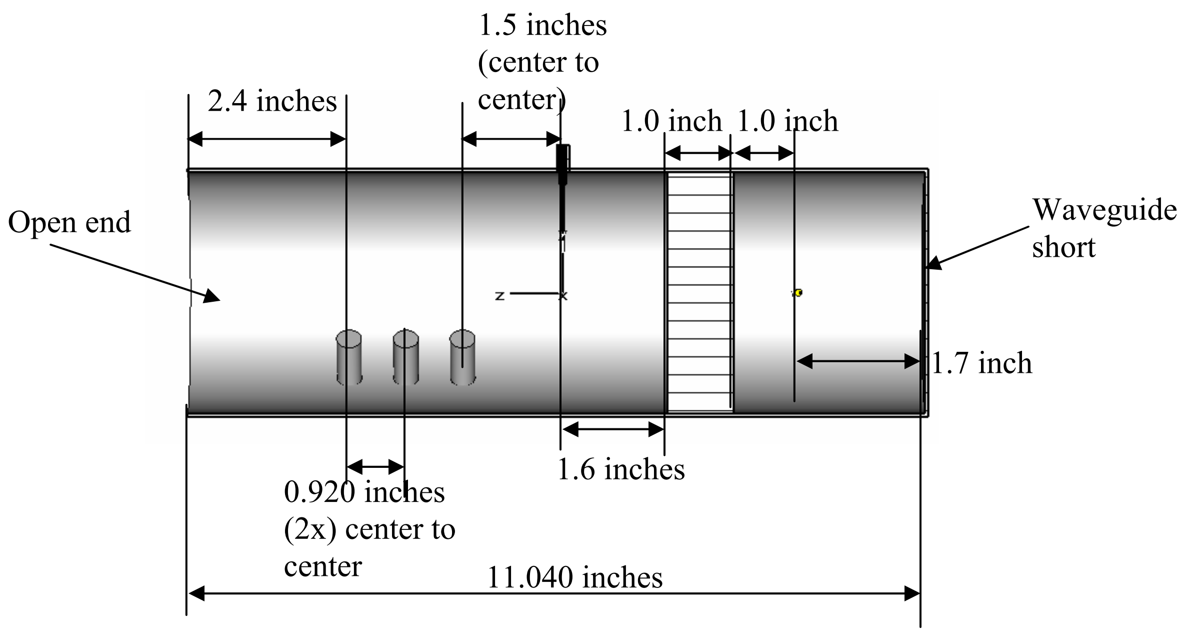
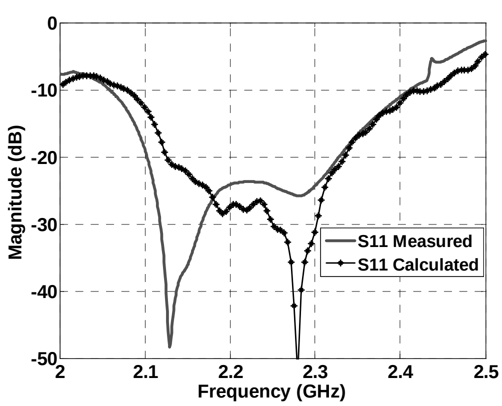


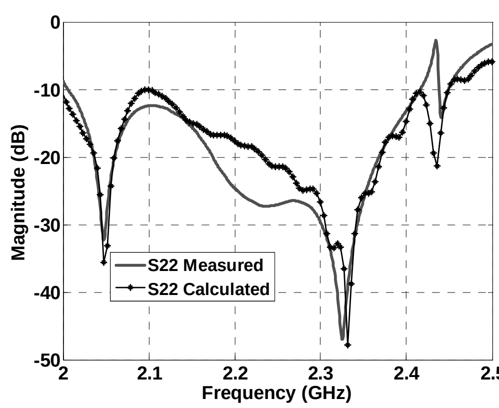
Figure 4 Dimensions for orthomode transducer (OMT) and polarizer.

Measured Data

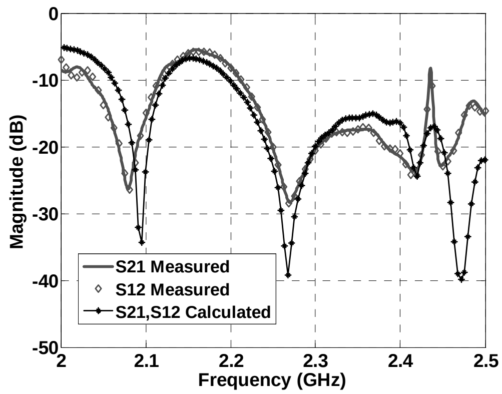
Figure 5 shows the measured and simulated return loss and the isolation for both ports. Measured directivity and axial ratio at a phi=0 cut at 2.25 GHz (the center frequency) are shown for port 1 in Figure 6, and for port 2 in Figure 7. The measured data showed excellent agreement with simulation, and the specifications were met for return loss, isolation, directivity and axial ratio.



(a)



(b)



(c)

Figure 5 Measured and simulated (a) S11, (b) S22 and (c) isolation for CCWA.

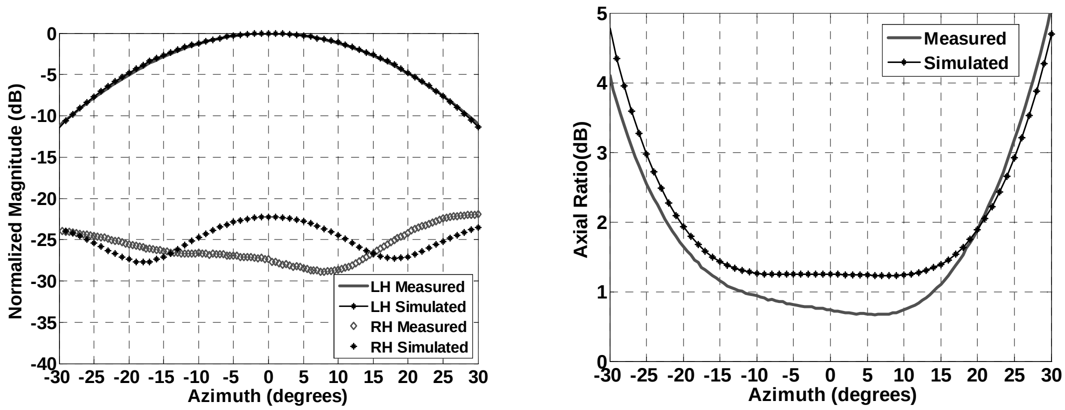


Figure 6 Measured and simulated (a) directivity and (b) axial ratio for Port 1, phi=90 degrees, at 2.25 GHz.

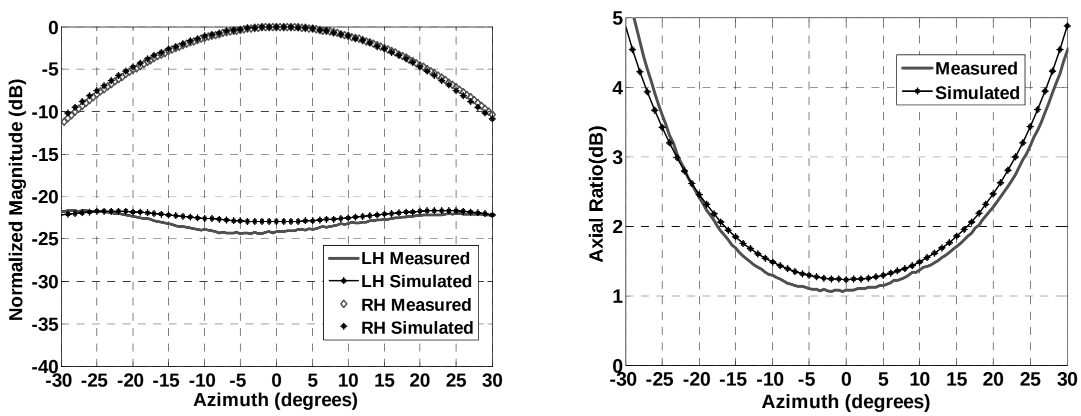


Figure 7 Measured and simulated (a) directivity and (b) axial ratio for Port 2, phi=90 degrees, at 2.25 GHz.

[i] Web Site for Goddard Space Flight Center TDRSS Project: http://tdrs.gsfc.nasa.gov/Tdrsproject/.

[ii] B. Subbarao and V. F. Fusco, Compact Coaxial-Fed CP Polarizer, IEEE Antennas and Wireless Propagation Letters, Vol. 3, 2004, pps. 145-147.

[iii] www.cst.com